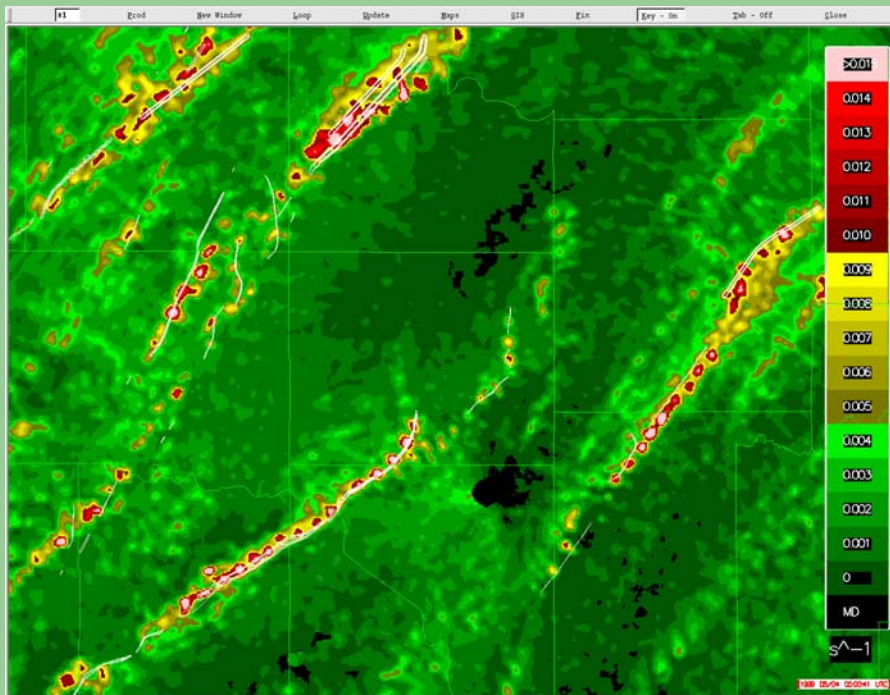


“Rotation Tracks” – A spatial history of circulation intensity and location



Travis M. Smith

NSSL / U. of Oklahoma
(CIMMS)

Travis.Smith@noaa.gov



A new paradigm of circulation history

- A complimentary product to the MDA and TDA algorithms, not a replacement
- Circulation ***location***, ***intensity***, and ***history*** are shown in ***one simple image***
 - Where were (are) the strongest storms, and how strong were (are) they?
- Does not suffer the limitations of the heuristic algorithms (TDA and MDA)

Linear Least Squares Derivatives (LLSD) of radial velocity data

- A filter for radial velocity data
- Typical kernel size of 2500m wide (cross-azimuth) by 750m deep (along-azimuth) highlights areas of mesocyclone-scale circulation – all points in the kernel are used, rather than just a “peak-to-peak” calculation
- Not a discriminator of tornadic versus non-tornadic circulations on its own.

Linear Least Squares Derivatives (LLSD) of radial velocity data

Azimuthal (rotational)
shear

$$u_s = \frac{\sum s_{ij} u_{ij} w_{ij}}{\sum (\Delta s_{ij})^2 w_{ij}}$$

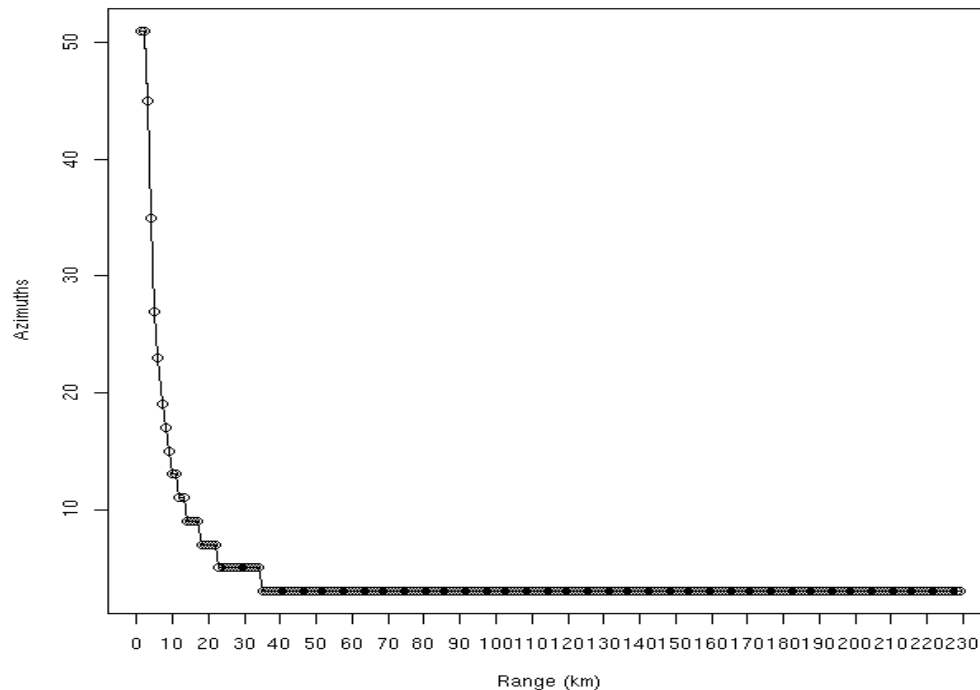
Divergent (along-
azimuth) shear

$$u_r = \frac{\sum i u_{ij} w_{ij}}{\Delta r \sum i^2 w_{ij}}$$

- u_{ij} is the radial velocity at point (i,j) in the kernel
- w_{ij} is a weighting function (uniform or Cressman)
- Δs and Δr are the pulse volume width (degrees) and depth (m)
- s_{ij} is the azimuthal distance from the center of the kernel to the point (i,j)

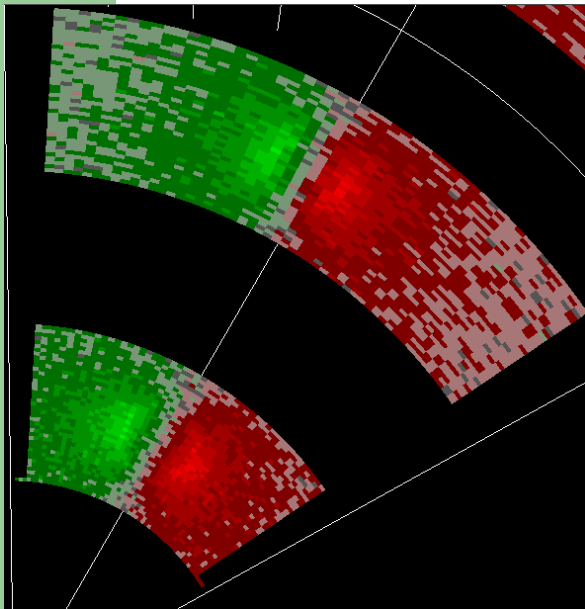
Linear Least Squares Derivatives (LLSD) of radial velocity data

- Number of azimuths required for kernel varies with range (3 minimum)

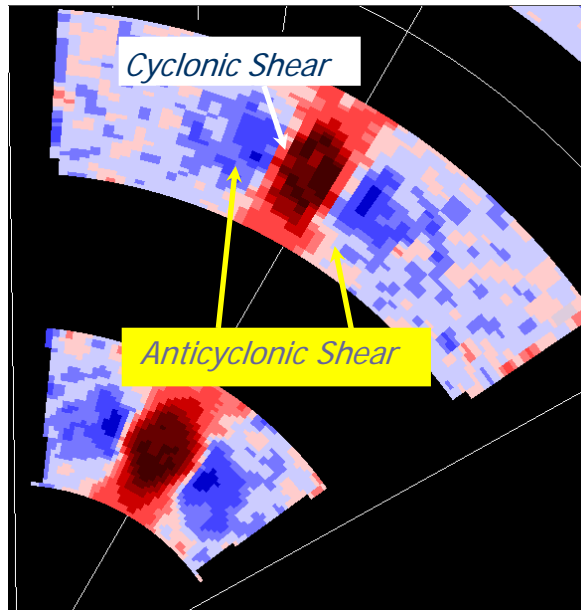


Linear Least Squares Derivatives (LLSD) of radial velocity data

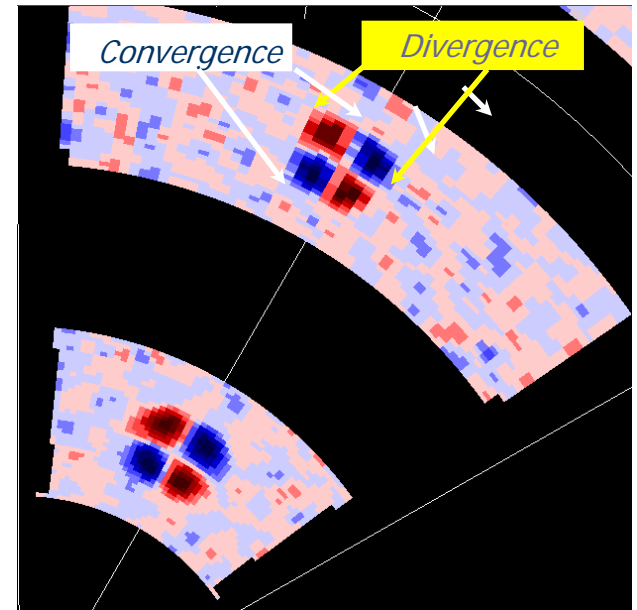
Simulated WSR-88D Velocity



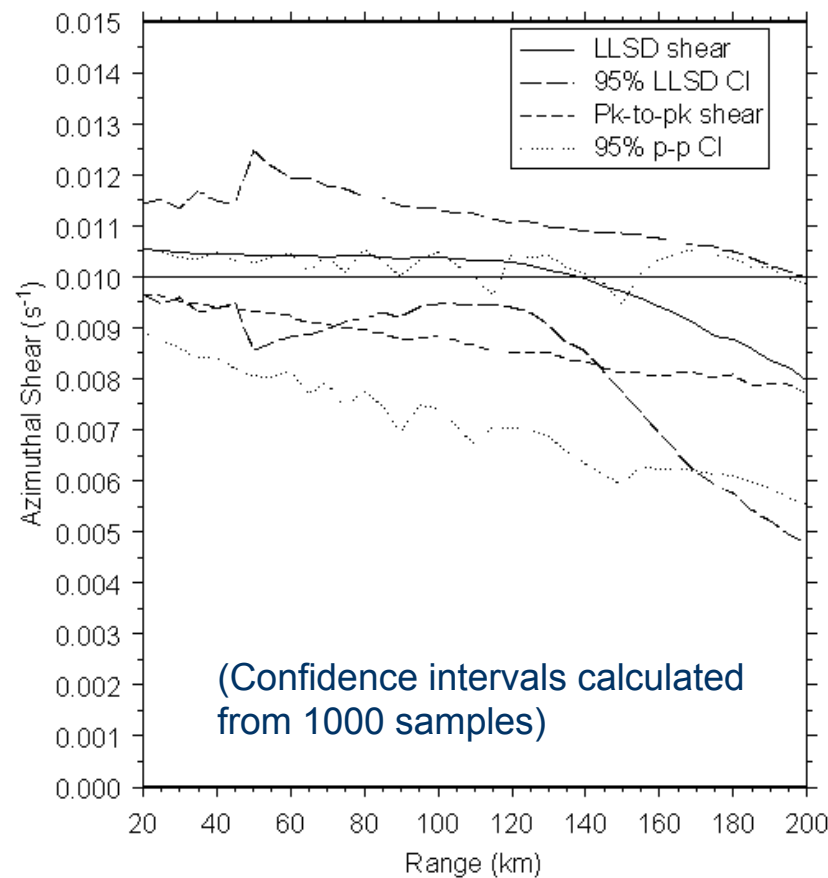
Azimuthal (rotational) Shear



Radial (Divergent) Shear

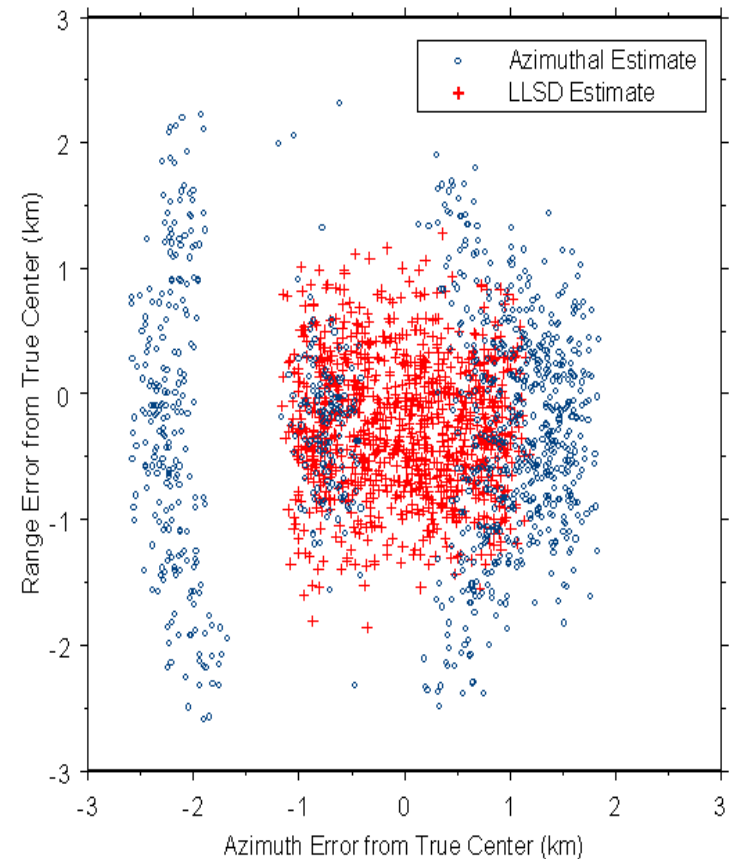


Rotational LLSD versus “Peak-to-Peak” azimuthal shear



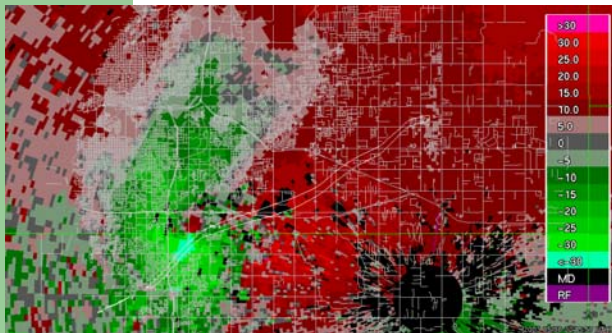
Rotational LLSD versus “Peak-to-Peak” azimuthal shear

- Location errors for determining the center of circulation is minimized by the LLSD method
 - Example: at 120 km range
 - LLSD versus a MDA-like calculation

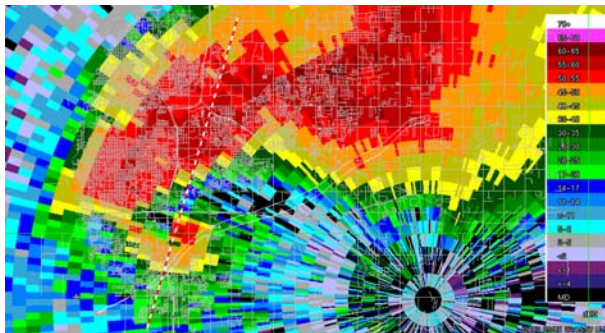


LLSD Azimuthal Shear in 3D

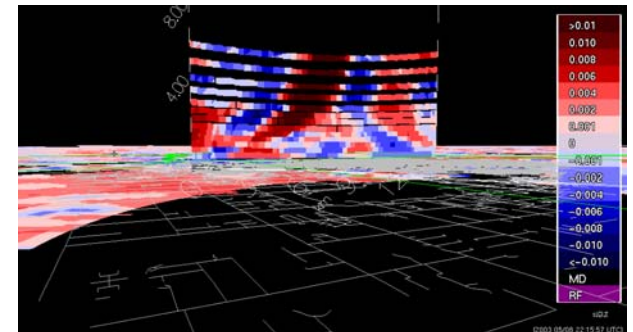
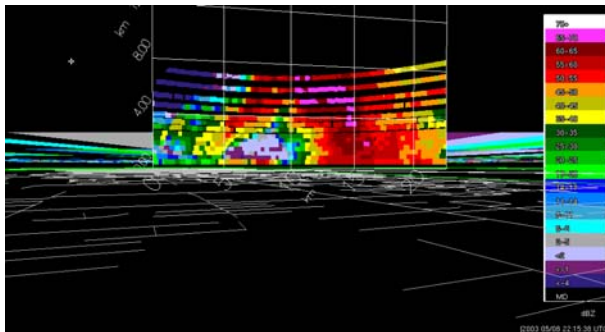
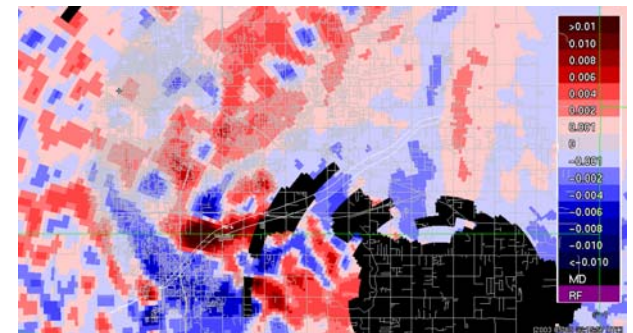
WSR-88D Velocity



Reflectivity



Azimuthal Shear



From LLSD to “Rotation Tracks”

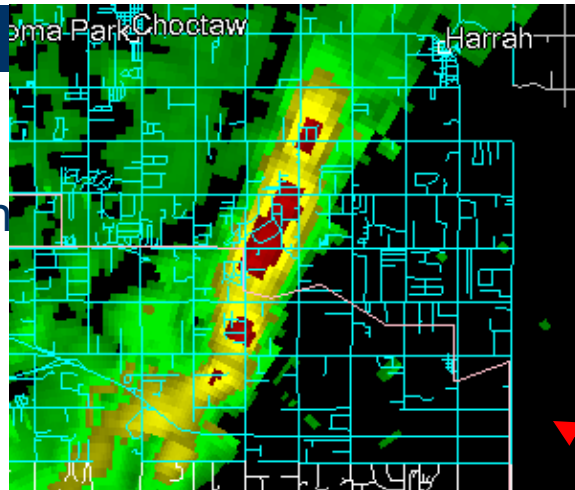
1. Median filter the velocity data
 - Removes data holes and noise, but
 - Also removes velocity peaks
2. Compute rotational LLSD (“half vorticity”)
3. Remove errors caused by velocity dealiasing failures
4. Remove data in low-reflectivity (non-precipitation) areas

From LLSD to “Rotation Tracks”

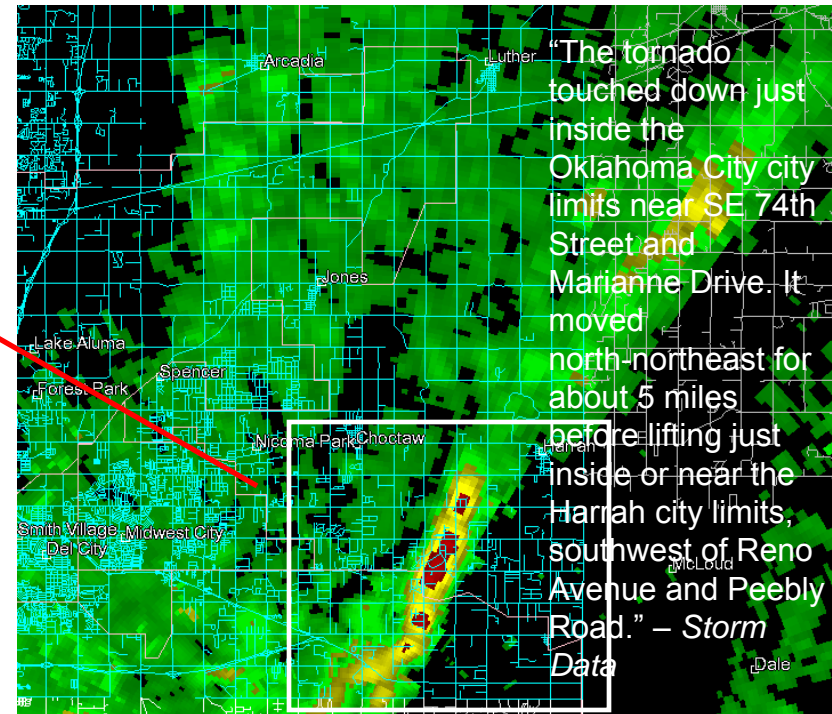
5. Calculate the max rotational shear in a layer (e.g. 0-3 km MSL; can use any user-specified levels OR environmental-based levels such as LCL)
6. Take the maximum value of rotational shear for each layer for specified time intervals (e.g. 2 hrs or 6 hrs)

Rotation Tracks: Benefits

High-resolution street maps



- Post-event verification: maps are printed out and given to storm damage assessment teams or emailed to emergency management officials
- No need to replay data – a process that can take hours.



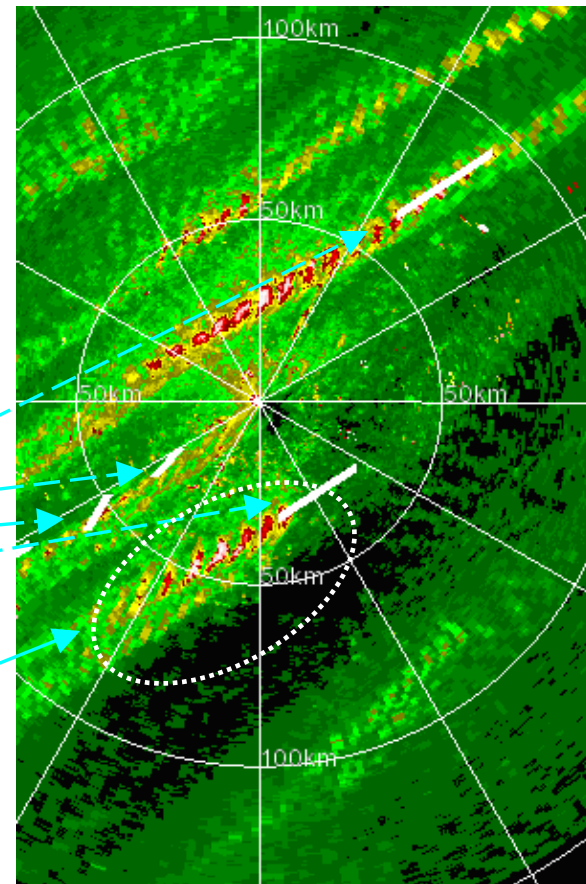
10 Apr 2005

Rotation Tracks: Benefits

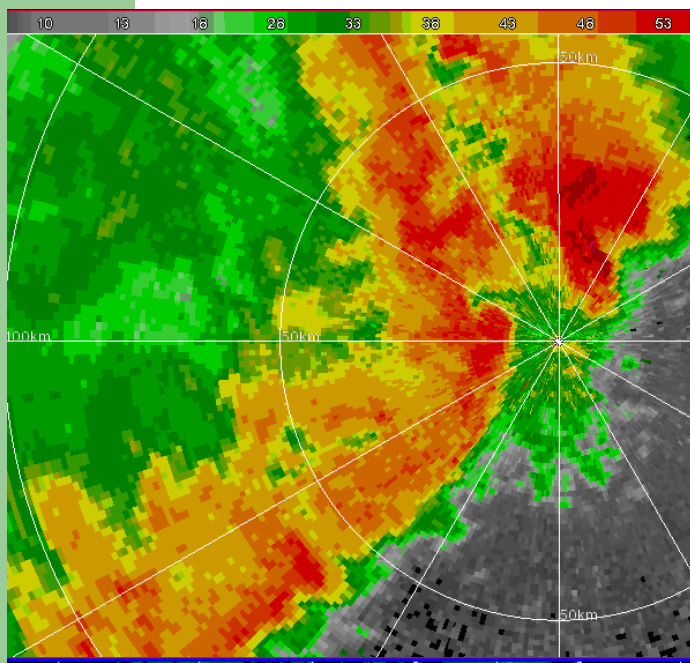
- Real-time assessment of circulation intensity

Damage paths as reported in *Storm Data* (white lines)

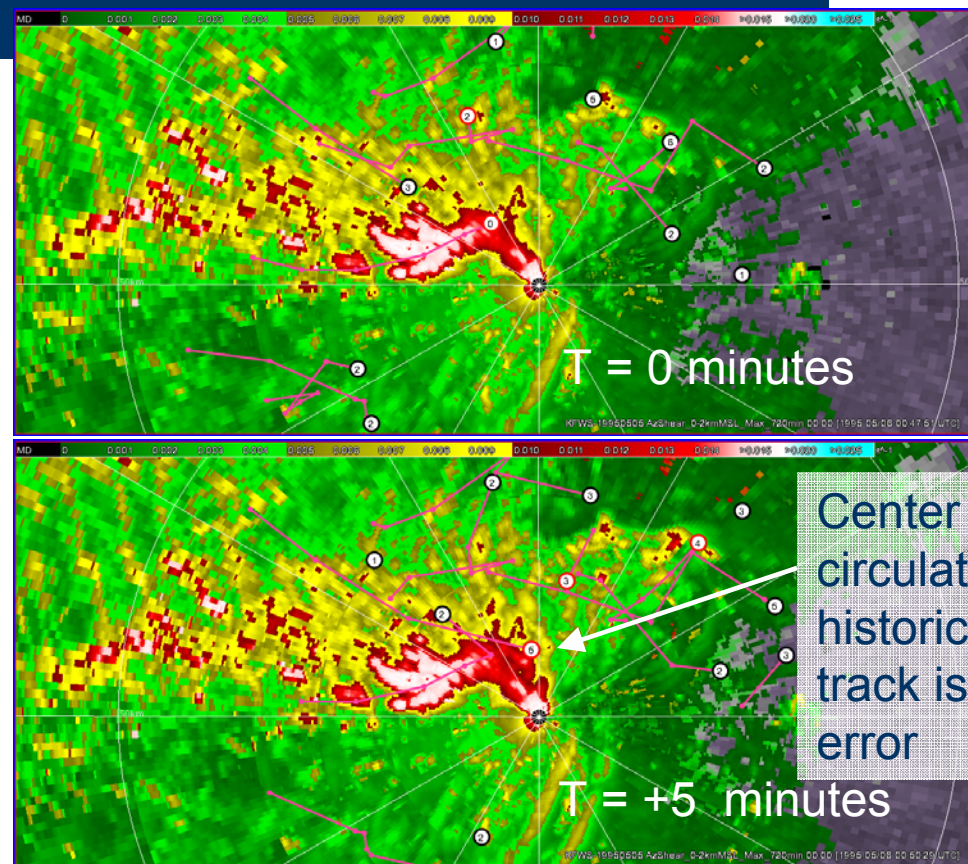
Rotation Track “in progress” (near time tornado begins)



Rotation Tracks and MDA historical tracks / trends

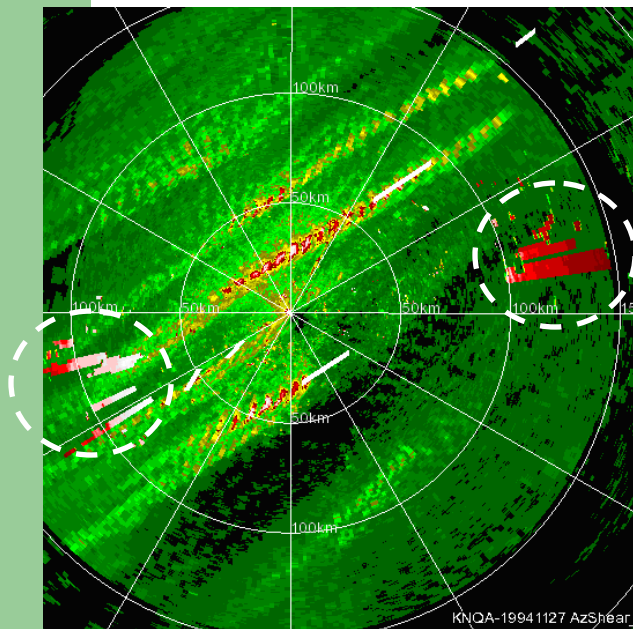


May 5, 1995 (KFWS)

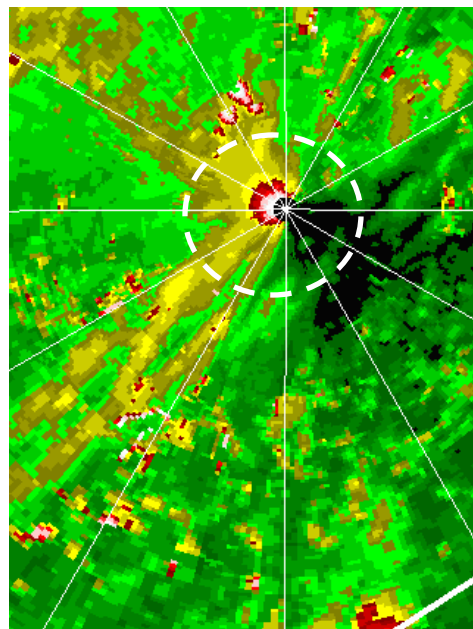


Poorly tracked MDA/TDA detections render the mesocyclone trend information useless!

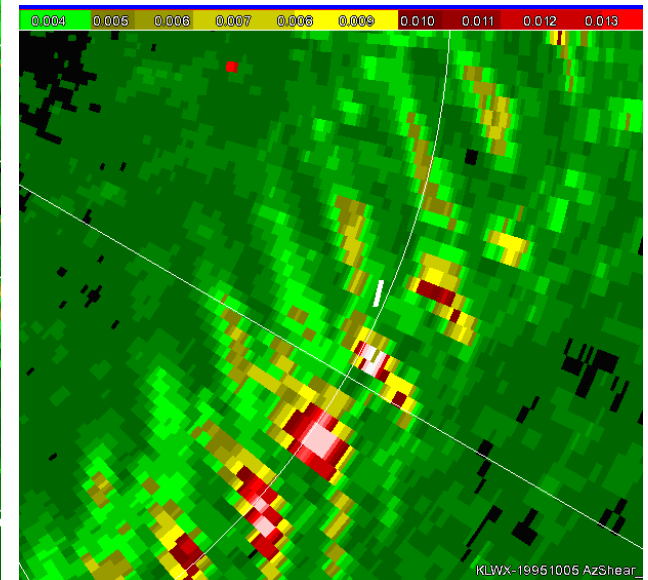
Some remaining, fixable, issues



Dealiasing errors can occasionally contaminate the track products



Vertical wind shear may cause a false rotation signature near the radar



“Splotchy” appearance caused by radar update rate. **Note: all other radar caveats apply!**

Rotation Tracks proof-of-concept testing

- Jackson, MS NWSFO 2002-2003
- Wichita, KS NWSFO 2003-2004
- Norman, OK NWSFO 2004-present
- St. Louis, MO NWSFO 2005-present

Surveys and other user feedback have been overwhelmingly positive

Rotation Tracks proof-of-concept testing

- Rotation Track maps continue to be used for post-event damage surveys by those offices that have access to them. An example from *Storm Data* (29 May 2004):
 - “This tornado was described by spotters as having a large funnel and as a possible "wedge" tornado, but no damage was reported (although power flashes were observed). The estimated track, based on spotters and NSSL Rotation Track maps from the Twin Lakes radar, began 5 miles SE of Meridian and continued NE across rural areas, ending just inside the Logan/Lincoln County line at 2125 CST, 6 miles east of Meridian. The parent mesocyclone occluded shortly thereafter, with a new one forming to the southeast.”
- May 9, 2003 (OUN) and Nov 10, 2002 (JAN) survey teams, among others.

Some Final Notes

- Evidence indicates that the Rotation Tracks product saves forecasters time and may improve verification efficiency (help meet GPRA goals by finding more tornadoes)
- Circulation *location*, *intensity*, and *history* are shown in *one simple image*
- There are still a few minor issues for which potential solutions exist.

Some Final Notes

- Integration with environmental data may further improve the products, but this would require either (a) passing environmental data to the ORPG or (b) generating the environmental-based products on an external machine such as AWIPS.
- Accommodates blending of data from multiple radars – data are not viewing-angle dependant.